(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 March 2001 (22.03.2001)

PCT

(10) International Publication Number
WO 01/20718 A1

(51) International Patent Classification[7]: H01Q 1/38

(21) International Application Number: PCT/SE00/01700

(22) International Filing Date: 4 September 2000 (04.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/153,345 10 September 1999 (10.09.1999) US

(71) Applicants *(for all designated States except US)*: **AVANTEGO AB** [SE/SE]; Box 511, S-184 25 Åkersberga (SE). **INTEGRA ANTENNAS LIMITED** [—/CN]; G031 Tech Center, HKUST, Clear Water Bay, Hong Kong (CN).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **ROWELL, Corbett** [—/US]; G031 Tech Center, HKUST, Clear Water Bay, Hong Kong (CN).

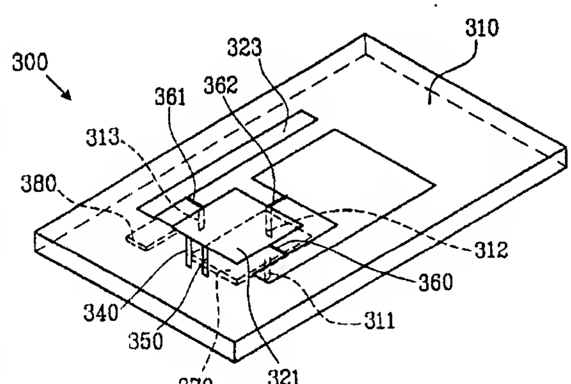
(74) Agent: **GÖTEBORGS PATENTBYRÅ DAHLS AB**; Sjöporten 4, S-417 64 Göteborg (SE).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

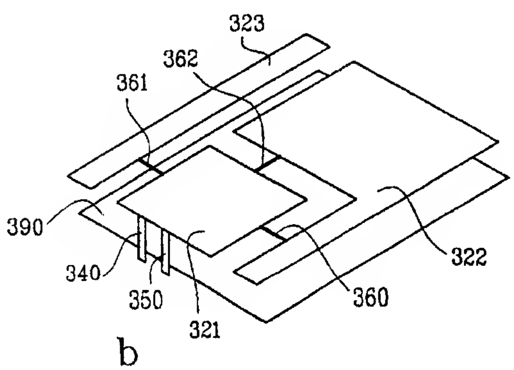
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European

[Continued on next page]

(54) Title: ANTENNA ARRANGEMENT



a



b

(57) Abstract: The present invention relates to an antenna arrangement (300, 400, 600, 700, 800, 900) of the type that comprises a plane of at least one radiating element (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 821, 921, 922) arranged relative a ground plane (390), at said least one of element being provided with feed (340, 440, 640, 740, 940) and/or ground connections (350, 450, 650a-650d, 750, 850, 950) and having a first electrical characteristic. The arrangement comprises at least one controllable switching arrangement (360, 361, 362, 460, 860, 961, 962), and that said radiating element (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723) is arranged to adopt at least a second electrical characteristic when said at least one controllable switching arrangement connects between a first and a second position and change a current path through said radiating element.

WO 01/20718 A1

patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

TITLE

ANTENNA ARRANGEMENT

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a method and an antenna arrangement for radiating electromagnetical waves. More specially, the invention relates to an antenna arrangement of the type that comprises a plane of at least one radiating element arranged relative a ground plane, at said least one of element being provided with feed and/or ground connections and having a first electrical characteristic.

BACKGROUND OF THE INVENTION

Wireless phones have traditionally used external antennas (whip and helix) for transmitting and receiving. These antennas radiate outward in all directions. When the phone is placed on a table or in a pocket, this radiation property is highly desired to ensure good reception. When the user talks on the phone, however, the body-loss-effect is up to 40% of this radiation. This body-loss-effect degrades the receiving and transmitting performances and is unwanted. Also the body-loss-effect effect the SAR value that is regulated from , e.g., FCC in US.

Recently, over the past two to three years, the mobile phone industry has started considering other antenna alternatives. many institutions have been researching “internal antennas.” These antennas are arranged inside the phone on top of a PCB. The PCB acts as mirror and an absorber, so the antenna’s radiation is directed away from the user. There is a cost, however, to this solution. By placing the antenna close to the PCB (which acts as a ground plane), other performance parameters are seriously decreased. The antenna’s operating bandwidth and peak gain both decreases. One method of increasing these parameters is to increase the available antenna volume. As the mobile phone market matures, however, the available antenna volume decreases as users demand smaller and lighter handsets.

In addition, there are multiple phone standards (or frequency bands) throughout the world and even inside single countries (i.e. GSM, DAMPS, CDMA, PCS, UMTS, etc.), increasing the

demand for "world-phones". These world-phones are beneficial to both the handset supplier and the end user. The user only needs one phone for vacations and business trips and the handset supplier has better logistics (fewer antenna types required). Internal antennas can only work in up to two of thcse frequencies bands - it would requirc a second external antenna for the phone to work in thrce or more frequency bands.

Wheeler's Law states that for a given antenna sizc there is a maximum attainable performance (in terms of bandwidth and efficiency). Moreover, there is continued demand for increase of antennas' performance by:

- Increasing the antenna's performance by increasing the size (as dictated by Wheeler's law), or
- by keeping thc performance the same, but using different techniques to enable the antenna to effectively operate over a larger frequency band.

There are so-called smart antennas for solving above-mentioned problems. These include a matching circuit as shown in fig. 1. A switch is arranged between the matching circuits for increasing the "effective bandwidth", and it is simple to implement. However, the drawbacks are difficulty of implementation for multiple frequencies and that they require "fast" diode switches.

It is also possible to place a varactor between the antenna and the PCB, as shown in fig. 2, which are usually placed in an arca with high electric field for greatest effect. The objccts are to increases thc bandwidth and provide more freedom than matching circuit switching. But this solution rcquires a "logic" circuit to find resonance and it is also difficult to implement for multiple band technology.

In yet another solution, an oscillator circuit is arranged near the feed of a balanced antenna. Thus, using a VCO, the loading circuit adjusts the natural resonance of the antenna to minimize the reflected power. This provides more tuning freedom than matching circuit switching, increases the effective bandwidth of balanced antcnnas and no feedback circuitry is required. But the solution is complex, requiring several components, it works only with balanced antennas and it is difficult to implement for multiple band solutions.

All the previous examples employ a variant of some type of "switching": i.e. change the inductive or capacitive loading conditions of the antenna to adjust its frequency.

Several other examples exist, c.g., adjusting position of ground connection (inductive loading), or changing dielectric properties below the antenna (capacitive)

Problems with these philosophies are: extending bandwidth +/- 30 to 50% from the antenna's natural resonance, and not being suited for tuning antennas across octave-bandwidths.

In order to cover multiple frequency bands without employing an external antenna (to keep radiation exposure low), a new type of antenna is required. The antennas discussed previously are considered passive antennas. Passive antennas do not change or adapt themselves to their environment. An active antenna contains a small circuit, which can adjust the antennas' properties according to its immediate environment. Typically, when the user places their hand over the phone, the antenna's properties change, usually by detuning the antenna (e.g. bad performance in the required frequency band).

Traditional active antennas use components as the only means of adjusting the antennas' properties (varactors and diodes). Using components to adjust the antenna limits the performance improvement over a narrow frequency band, due to losses and inherent properties of these components.

SUMMARY OF THE INVENTION

An active antenna according to the invention will change its own properties to adapt to different hand positions on the phone, optimizing the handset performance. The circuit can be used to allow the internal antenna to cover several frequency bands. The antenna is switched between frequencies using the circuit. A third use of active antennas is to integrate diversity functions into a single antenna. The circuit can be used to switch polarizations in a single antenna. (Traditional diversity antenna systems need more than one antenna, using more volume within the phone.) The

active antenna can greatly enhance thc properties of an internal antenna within futurc mobile phone technologies.

Thus, the main object of the prcsent invcntion is to solve the abovc-mentioned problems related with the prior art.

Other benefits of the present invention will be understood through reading the specification in conjunction with the described exemplary cmbodiments.

For these reasons, in the initially mentioned antenna arrangement said arrangement comprises at least one controllable switching arrangement and that said radiating element is arranged to adopt at least a second electrical charactcristic when said at least one controllable switching arrangement connects between a first and a second position and change a currcnt path through said radiating element.

In one embodiment, the arrangement comprises at least two radiating elements. The switching arrangement electrically connects between said radiating elements and reconfigures geometrical characteristics of said elements upon reception of a control signal. Preferably, the switching arrangement is one of a diode, transistor, MEM or piezoelectric element etc.

According to a first aspect of the invention, the antenna arrangement comprises of a carrier, on one surface provided with a layer of separated patchcs, constituting the radiating antenna elements, a first patch containing feed and ground connections, thc remaining patch(es) being isolated from the first patch, between said isolated patches and the first patch being arranged a network of switches being connected to a control circuit. The control circuit has a scparate ground, which is isolated from said antenna by quarter wave microstrip lines and operates through connection to several different levcls of voltage. The voltage enters a voltage comparator, which turns said network of switches on and off according the voltage level. The control circuit has an input analog voltage, whereby an A/D-converter converts an analog signal to a digital signal to control said switches between said antenna patchcs. Preferably, the switches are ground isolated from said antenna element using l/4 microstrip lincs. Moreovcr, the switching is slow bctween

frequency bands and can accommodate either analog input or digital input for antenna control. The patches are switched on and off, forming different geometries of the antenna.

According to a second aspect of invention, the antenna arrangement comprises a carrier, on which a number of radiating elements in form of conductive films are arranged and at least one switch is arranged there between. The switch is connected to a control signal via a resistor and a LC network.

In one embodiment, at least one radiating element is provided with additional feed or ground connections, which are provided with switches to through switching allow change of the a current path through the radiating element.

In another embodiment, the antenna arrangement comprises at least four input lines, feed, ground, serial digital input and clock. The serial digital bits, from the communication device circuitry are converted into a set of parallel bits, which then controls the set of switches. The conversion is achieved by means of a serial-to-parallel converter controlled by said clock signal.

It is also possible to arrange the antenna element substantially meander shaped.

In one embodiment, the feed is connected to the antenna through a capacitive feeding arrangement.

In one embodiment two or more switches are arranged between a first active patch and a second passive patch.

The invention also relates to a method of changing said characteristic in antenna arrangement of the type that comprises a plane of at least one radiating element arranged relative a ground plane, at said least one of element being provided with feed and/or ground connections and having a first electrical characteristic. The method comprises arranging at least one controllable switching arrangement, and connecting between a first and a second position

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be further described in a non-limiting way with reference to the accompanying drawings in which:

Fig. 1 is a schematic illustration of a solution according to the prior art,

Fig. 2 is another schematic illustration of a solution according to the prior art,

Fig. 3a is schematic view of a first embodiment of an antenna arrangement in perspective, according to the invention,

Fig. 3b is an enlarged view of the antenna element according to fig. 3a,

Fig. 4 is schematic view of a second embodiment of an antenna arrangement in perspective, according to the invention,

Fig. 5 is a cross-sectional view along line V-V in fig. 4,

Fig. 6 is a third embodiment of an antenna arrangement according to the invention,

Fig. 7 is a fourth embodiment of an antenna arrangement according to the invention,

Fig. 8 is a fifth embodiment of an antenna arrangement according to the invention, and

Fig. 9 is a sixth embodiment of an antenna arrangement according to the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention involves integrating a circuit into the antenna structure itself. This new type of antenna is no longer dependent on the characteristics of the circuit components. It operates over a much wider frequency band with little decrease in performance (compared to the theoretical optimum antenna). The antenna according to the invention is able to optimize the phones' performance while keeping the body-loss-effect low.

Rather than adjusting the loading of the antenna, the physical geometry of the antenna is changed, which allows the antenna to be switched between frequency bands or polarizations, and fulfils two rules:

- The feed and ground connections are connected via a base patch , and
- remaining patches are parasitic elements when switched off.

In one basic embodiment, the antenna consists of an N-by-N grid, including 1 by 1, array of metal (conductive) patches. The metal patches can be of arbitrary shape and size and for simplicity, rectangular elements are used. The antenna is located above a ground plane (either partially or entirely). Between each element and its neighbor are switches. This antenna is intended for mobile phone or other communication device use and may be tightly integrated with the RF receiver chain. These switches may consist of diodes, transistors, or micromachined elements. The switches can be controlled by a FPGA or by setting the input voltage level into the antenna. The FPGA (Field Programmable Gate Array) consists of a bank of transistors designed to reconfigure itself, depending on the data input. When the FPGA reconfigures itself, these signals are passed on down to the switches in the N-by-N antenna array. The other option is to use a voltage level to set the switching pattern on the N-by-N antenna array. Within this array of antenna elements is the feeding element. In this embodiment (1x1) feed and ground are connected to the feeding element.. The connection to ground is required for size reduction. The additional antenna elements may consist of 2-D patches or capacitive loads, where one section of the element is closer to ground than the rest of the element. By controlling the switching of the antenna elements, there are several different applications for this antenna system, for example: Multiple band antennas, i.e. 4 to 5 frequency bands on the same antenna, finger effects, i.e. adjust the resonant frequency to compensate loss of performance due to the user shifting their finger on the back of the mobile handset, and SAR, which means by controlling the direction of the currents, this can reduce the amount of body-loss-effect..

One embodiment of the antenna 300, as shown in figs. 3a and 3b, comprises of a double-sided PCB 310. On the upper surface a network of separated patches 321-323, constituting the radiating antenna elements, is arranged. A first patch 321 (active patch) contains feed and ground connections, 340 and 350, respectively, to the handsets' PCB 310. The remaining patches 322 and 323 are isolated from the feeding patch. Between the isolated patches and the feeding patch is a network or a bank of switches 360-362. The RF switching may include diodes, transistors, MEMs, piezoelectric elements etc. This network of switches is connected through vias 311-313 to the opposite side of the PCB with the control circuit 370. The patches are arranged above a ground plane 390 (not shown in fig. 3a for clarity reason), covering it at least partly. The active

patch 321 may also comprise of a switching center (not shaped as a patch). Moreover, the active patch does not need to be connectcd to both feed and ground connections. It may only be connected to one of ground or feed connections.

The space between the ground plane and the patches may contain air or a diclectric spaccr means, which allows reduction of size.

The control circuit 370 has a separate ground, which is isolated from the antenna by quarter wave microstrip lines (not shown). The control circuit works by accepting several different levels of DC voltage (e.g., A= 1 V, B=1.5V, C=2.0V, etc.) The voltage cnters a voltage comparator, which then turns the network of RF switches on and off according to the voltage level. Since the controlling circuit is DC and the RF switchcs arc "slow", there is no inter-modulation between the antenna and the control circuit (a common problem with past active antennas). Since there is no inter-modulation between the controlling circuit and the AC current in the antenna, the controlling circuit does not need to be isolatcd from the antenna (i.e. with a form of shielding, or grounding). Previous active antennas need to have this shielding which affects the performance of the antenna. In addition, this allows the controlling circuit to be integrated together with the antenna, simplifying production and resulting in a more mechanically stable antenna.

The control circuit can bc very simple. In one embodiment, it has an input analogue voltage of x volts, an A/D-converter converts an analogue signal to 1=s and 0=s to control the switches between antenna patches for cxample:

- Vin = 1 V, Diode Switch Pattern = {0 0 1},
- Vin = 2 V, Diode Switch Pattern = {1 0 1}, etc.

Diodes can be ground isolated from antenna using l/4 microstrip lines. Switching is "slow" between frcquency bands and can accommodatc either analogue input or digital input for antenna control. The concept is extendable to diversity antennas, frequency tuning, etc.

Thus, the patches on the uppcr layer of the PCB are switched on and off, forming different geometries of the antenna. These different geometries are primarily metal plates and therefore

have excellent conductivity and good radiation efficiency. The patches can be slowly switched (about once every few minutes up to once every few days) from one frequency band to another (i.e. from GSM to UMTS or PCN). These slow switches do not interfere with the phone's circuitry (as explained above).

Fig. 4 shows a second embodiment of an antenna arrangement 400 according to the invention. The antenna comprises a carrier 410, on which a number of radiating elements 421 and 422 are arranged. The radiating elements are conductive films adhered or in a suitable way attached to the carrier 410. The first element 421 is fed and connected to ground through connections 440 and 450, respectively. A switching element 460 is arranged between the radiating elements. A ground plane (not shown) is arranged inside the carrier under the radiating elements.

Fig. 5 is a schematic cross-section along line V-V in fig. 4. The switch 460, for example a diode, is connected between the elements 421 and 422. In the carrier a hole 501 is arranged through which the switch is connected to a control signal via a resistor 503 and a LC network comprising an inductive element 502 and a capacitive element 504. The inductive element 502, e.g. an inductance, is arranged to eliminate the feedback of radiofrequency signals. The capacitive element is arranged between the ground and the input signal.

In yet another embodiment, as shown in fig. 6, it is also possible to provide one or several of the patches 621- 623 with additional feeding or ground connections 650a-650d. Then, it is possible to change the antenna configuration by switching between the connections to change the current path through the patches. The connection can only be provided when a patch other than the main patch 621 is interconnected to the main patch or another patch provided with a feeding connection (according to this embodiment).

In another embodiment of the antenna arrangement, as shown in fig. 7, the antenna 700 requires four input lines: feed 740, ground 750, serial digital input 780, and clock 790. The serial digital bits (from the phone circuitry, not shown) are converted into a set of parallel bits, with a serial-to-parallel converter 795 controlled by the clock signal 790, which then controls the set of switches embedded within the antenna. The advantage with this antenna is that no analog input/connection

required as some handsets try to minimize the analog components within the phone. In this configuration, only a digital input/connection is required.

Fig. 8 shows another embodiment of an antenna 800, in which an antenna element 821, substantially meander formcd, is arranged above a ground plane 890. A switch center 805 is arranged to feed different positions of the antenna element. Each connection to the antenna element may also be substituted with separate switches of above-mentioned type. The antenna element is connected to ground through connection 850.

In the embodiment of fig. 9, the antenna arrangement 900 comprises a first patch 921 and a second, substantially U-shaped patch 922, both arranged relative to a ground plane 990 and electrically isolated from each other. The first patch 921 may be connected to the feed and ground connections, not shown for simplicity. The first patch 921 can be electrically connected to the second patch 922 through switches 961 and 962. By connecting the first patch to the second patch in different positions through the switches the electrical characteristics of the antenna is changed, thus providing different antenna characteristics.

It is also possible to connecting thc feed to the antenna through a capacitive feeding arrangement, instead of a galvanic connection.

It is also possible to arrange two or more switches between the active patch (321, 421, 621 721) and one of the passive patchcs (can extend up to a "bank" of switches). This allows more "space" for the current flow between patches when the switches are on.

The antennas dcscribed here can be used in any dcvicc having need for transmitting and/or receiving electromagnetic radiation, such as for example cellular phones, any radio dcvice, PCMCIA cards, Blutooth devices, etc.

The invention is not limited the shown embodiments but can be varied in a number of ways without departing from the scope of the appended claims and the arrangement and the method can

be implemented in various ways depending on application, functional units, needs and requirements etc. Obviously, a combination of all embodiments is also possible.

CLAIMS

1. An antenna arrangement (300, 400, 600, 700, 800, 900) of the type that comprises a plane of at least one radiating clement (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 821, 921,922) arrangcd relative a ground plane (390), at said least one of element being provided with feed (340, 440, 640, 740, 940) and/or ground connections (350, 450, 650a-650d, 750, 850, 950) and having a first electrical characteristic,

characterized in

that said arrangement comprises at least one controllable switching arrangement (360, 361, 362, 460, 860, 961, 962), and that said radiating element (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723) is arranged to adopt at least a second electrical characteristic when said at least one controllable switching arrangement connects between a first and a second position and change a current path through said radiating element.

2. The antenna arrangement of claim 1,

characterised in

that the arrangement comprises at least two radiating elements (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 921,922).

3. The antenna arrangement of claim 2,

characterised in

that said switching arrangement (360, 361, 362, 460, 961, 962) electrically connects between said radiating elements (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 961, 962) and reconfigures geometrical characteristics of said elements upon reception of a control signal.

4. The antenna arrangement of claim 1,

characterised in

that said switching arrangement (360, 361, 362, 460) is one of a diode, transistor, MEM or piezoelectric elemcnt etc.

5. The antenna arrangement of any of claims 2-4,

characterised in

that the antenna arrangement (300) comprises of a carrier (310), on one surface provided with a layer of separated patches (321-323), constituting the radiating antenna elements, a first patch (321) containing feed and ground connections (340; 350), the remaining patch(es) (322, 323) being isolated from the first patch, between said isolated patches and the first patch being arranged a network of switches (360-362) being connected to a control circuit (370).

6. The antenna arrangement of claim 5,

characterised in

that the control circuit (370) has a separate ground, which is isolated from said antenna by quarter wave microstrip lines

7. The antenna arrangement of claim 5 or 6,

characterised in

that the control circuit operates through connection to several different levels of voltage.

8. The antenna arrangement of claim 7,

characterised in

that the voltage enters a voltage comparator, which turns said network of switches on and off according the voltage level.

9. The antenna arrangement according to any of claims 5-8,

characterised in

that the control circuit has an input analog voltage, whereby an A/D-converter converts an analog signal to a digital signal to control said switches between said antenna patches.

10. The antenna arrangement according to any of claims 5-9,

characterised in

that the switches are ground isolated from said antenna element using 1/4 microstrip lines.

11. The antenna arrangement according to any of claims 5-10,

characterised in

that switching is slow between frequency bands and can accommodate either analog input or digital input for antenna control.

12. The antenna arrangement according to any of claims 6-11,
characterised in
that said patches are switched on and off, forming different geometries of the antenna.

13. The antenna arrangement according to claim 1,
characterised in
that the antenna arrangement (400) comprises a carrier (410), on which a number of radiating elements (421, 422) in form of conductive films are arranged and at least one switch (460) is arranged there between.

14. The antenna arrangement according to claim 1,
characterised in
that said switch (460) is connected to a control signal via a resistor (503) and a LC network.

15. The antenna arrangement according to any preceding claims,
characterised in
that at least one radiating element is provided with additional feed or ground connections (650a-650d), which are provided with switches to through switching allow change of the a current path through the radiating element.

16. The antenna arrangement according to claim 1,
characterised in
that the antenna arrangement (700) comprises at least four input lines, feed (740), ground (750), serial digital input (780) and clock (790).

17. The antenna arrangement according to claim 15,
characterised in
that serial digital bits, from the communication device circuitry are converted into a set of parallel bits, which then controls the set of switches.

18. The antenna arrangement according to claim 17,
characterised in
that said conversion is achieved by means of a serial-to-parallel converter controlled (795) by said clock signal (790).

19. The antenna arrangement according to claim 1,
characterised in
that said antenna element is substantially meander shaped.

20. The antenna arrangement according to any of preceding claims,
characterised in
that the feed is connected to the antenna through a capacitive feeding arrangement.

21. The antenna arrangement according to claim 2,
characterised in
that two or more switches are arranged between a first active patch (321, 421) and a second passive patch.

22. A communication device comprising an antenna arrangement according to any of claims 1-20.

23. In antenna arrangement (300, 400, 600, 700, 800, 900) of the type that comprises a plane of at least one radiating element (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 821, 921,922) arranged relative a ground plane (390), at said least one of element being provided with feed (340, 440, 640, 740, 940) and/or ground connections (350, 450, 650a-650d, 750, 850, 950) and having a first electrical characteristic, a method of changing said characteristic,
characterised by
arranging at least one controllable switching arrangement (360, 361, 362, 460, 860, 961, 962), and connecting between a first and a second position
producing at least a second electrical characteristic in said radiating element (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 821, 921, 922) by controlling said at least one controllable switching arrangement to connect between a first and a second position.

24. The method of claim 23,

characterised in

that the arrangement comprises at least two radiating elements (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 921,922).

25. The method of claim 24,

characterised by

electrically conncting by said switching arrangement (360, 361, 362, 460, 961, 962) between said radiating elements (321, 322, 323, 421, 422, 423, 621, 622, 623, 721, 722, 723, 961, 962) and reconfiguring geometrical characteristics of said elements.

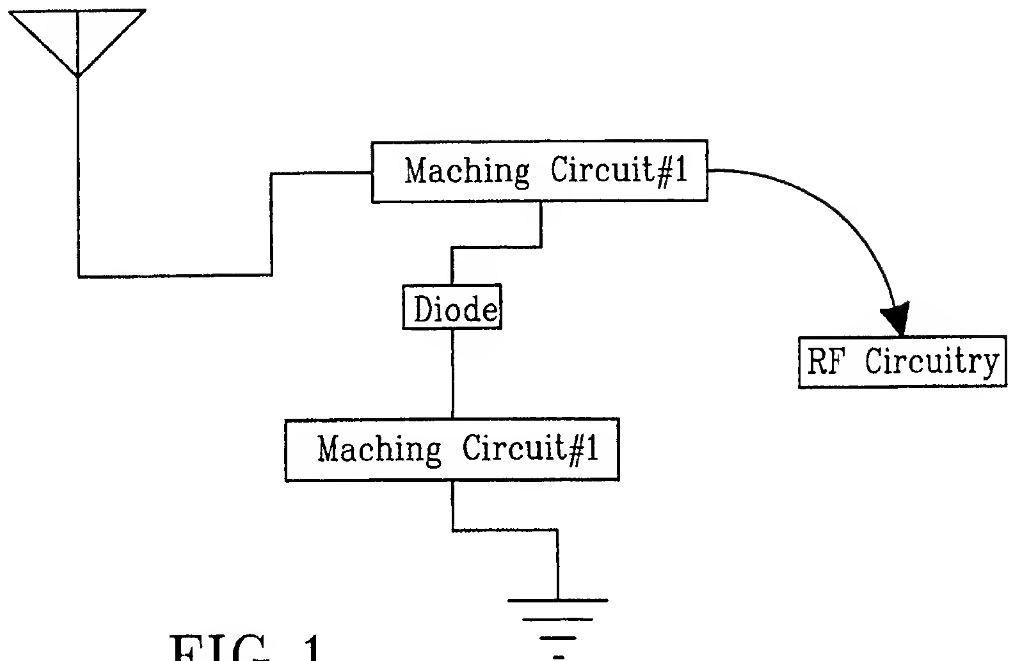

Maching Circuit#1
Diode
RF Circuitry
Maching Circuit#1

FIG. 1

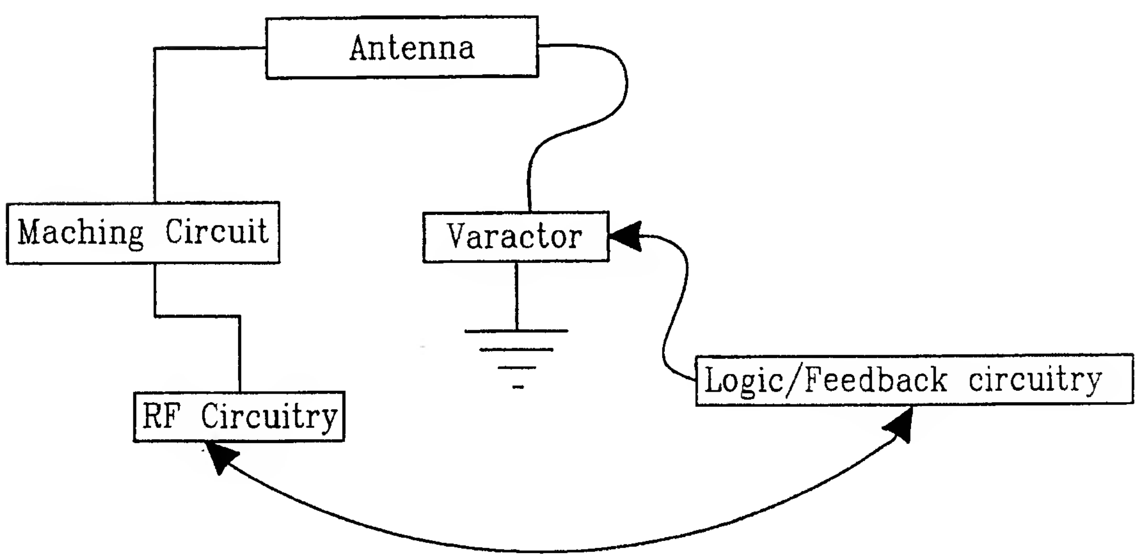

Antenna
Maching Circuit
Varactor
RF Circuitry
Logic/Feedback circuitry

FIG. 2

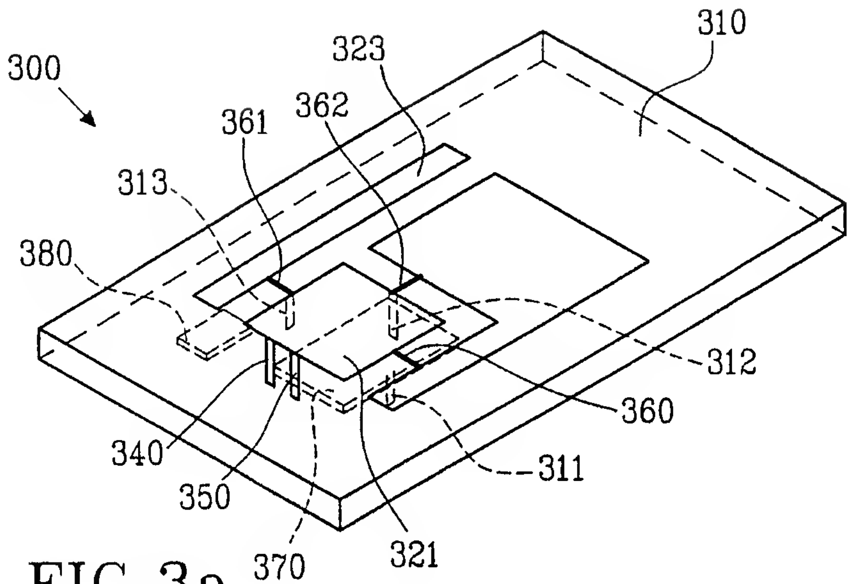

300
323
310
361
362
313
380
312
360
340
311
350
370
321

FIG.3a

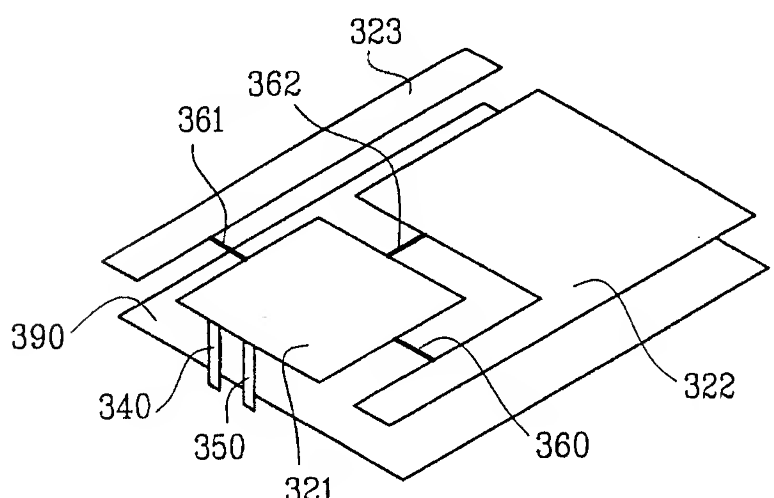

323
362
361
390
322
340
360
350
321

FIG.3b

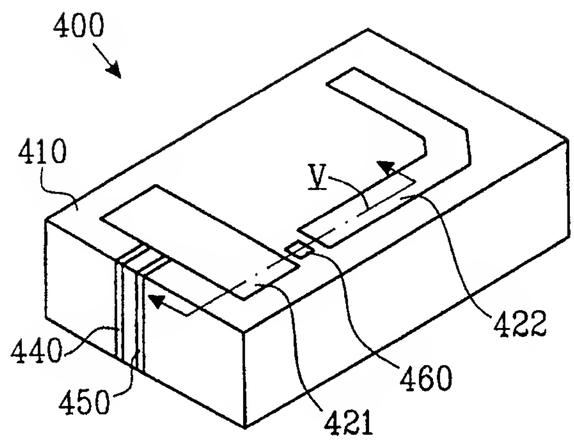

400
410
V
422
440
460
450
421

FIG.4

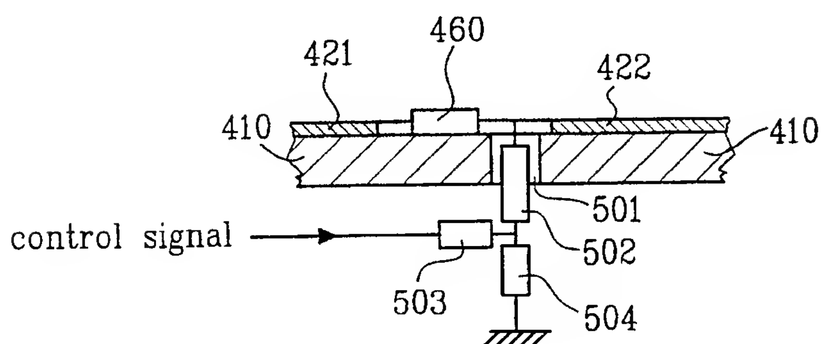

460
421
422
410
410
501
control signal
502
503
504

FIG.5

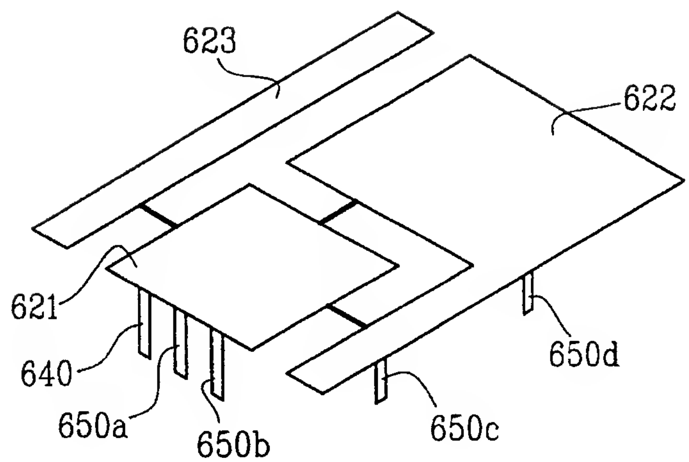


FIG.6

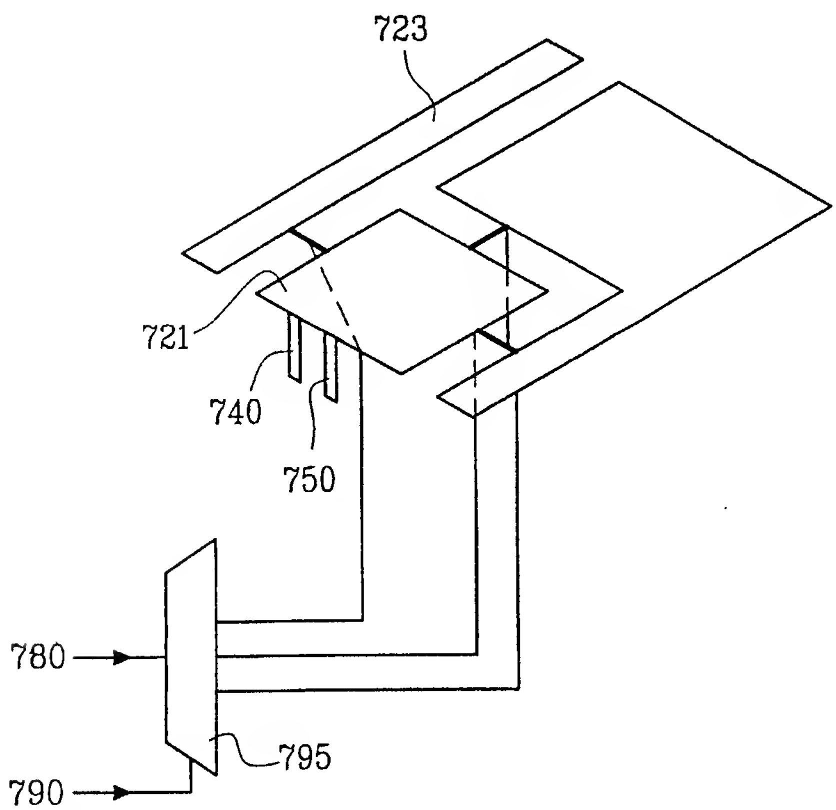


FIG.7

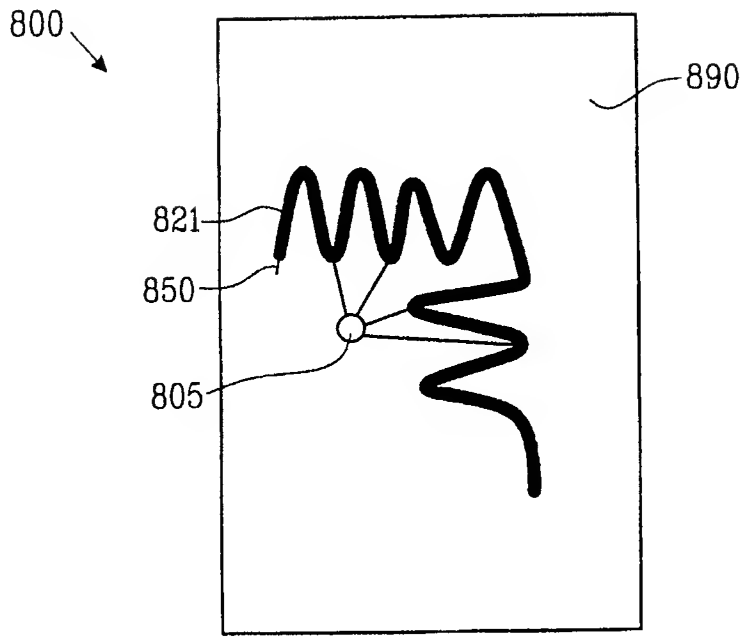


FIG.8

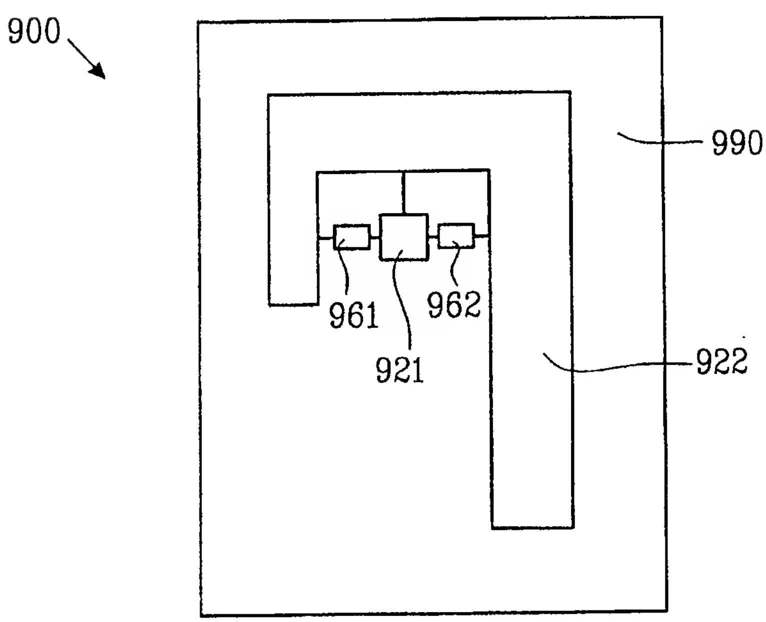


FIG.9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01700

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	GB 2335798 A (NEC TECHNOLOGIES (UK) LTD), 29 Sept 1999 (29.09.99), see the whole document --	1-25
A	US 5394159 A (M.V. SCHNEIDER ET AL.), 28 February 1995 (28.02.95), figures 2-4, abstract --	1-25
A	WO 9903168 A1 (ALLGON AB), 21 January 1999 (21.01.99), figures 4-9, abstract -- --------	1-25

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 December 2000	18-12-2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson/AE Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

04/12/00

International application No.
PCT/SE 00/01700

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
GB	2335798	A	29/09/99	GB	9806507	D	00/00/00
US	5394159	A	28/02/95	CA	2128763	A	03/05/95
				EP	0651459	A	03/05/95
				JP	7193424	A	28/07/95
WO	9903168	A1	21/01/99	AU	7560398	A	08/02/99
				AU	8365998	A	08/02/99
				CN	1261988	T	02/08/00
				CN	1262791	T	09/08/00
				EP	0995231	A	26/04/00
				EP	0996992	A	03/05/00
				SE	511501	C	11/10/99
				SE	9702659	A	10/01/99
				WO	9903166	A	21/01/99
				SE	9800899	A	19/09/99
				WO	9947365	A	23/09/99

Form PCT/ISA/210 (patent family annex) (July 1998)